

The international space station is one of humanity's great engineering triumphs. But now NASA has to face a difficult question: what is it for?

Many astronauts do their best to connect to the earthlings. Astronauts tweet and update Facebook pages. A few months back, Hadfield made a humdinger of a music video — [covering David Bowie's song "Space Oddity"](#) — that has more than 17 million views on YouTube.

Hadfield also made videos about everyday life in space. Bodily fluids go in strange directions. Your vision blurs, your nose feels stuffy, and you lose your sense of taste.

Water is so dominated by surface tension that it can migrate around your scalp and over your face, as if seeking a hole to invade.

In zero gravity, a flame burns spherically — a ball of fire.

Experiments on the ISS have touched on fluid dynamics, crystal formation and changes in bacterial virulence. Next year, 20 to 60 rodents will come aboard as research subjects. And the astronauts themselves are under the microscope, revealing the effects of weightlessness and space radiation. NASA and the Russian Federal Space Agency plan to send astronauts [to the ISS for an entire year](#), starting in the spring of 2015.

Astronauts talk about the transcendent experience of seeing the world without political borders, with the thin blue line of the protective atmosphere. Hadfield would often know where the station was over the surface, simply by checking out the color of the light shining up through the cupola, the nest of windows facing the planet. Usually the light would have a blue cast, from the ocean below. If orange, that would usually mean the station was passing over the Sahara. If red, that would be the signal of the Outback.

A support diver takes position underwater at the Johnson Space Center during a spacewalk training exercise. [Click here for a photo gallery.](#) (Ricky Carioti/The Washington Post)

A typical work shift lasts 12 hours. Astronauts get one day off a week, a respite from the grind of chores and scientific experiments. Satellite TV reception in space is poor, oddly enough. Smoking and drinking are not allowed. Bodies deteriorate without gravity, and so the astronauts exercise constantly, at least two hours a day.

Astronaut Nicole Stott said she has never slept better in her life than she did in space. No pillow necessary. There are no pressure points on the body. A chronic pain in her arm simply disappeared forever. The only problem with space sleep is that the body naturally forms a zombielike pose, with arms

dangling forward.

“It’s kind of scary,” she said.

Saturdays are cleaning days. Every surface is essentially a floor, gathering dirt, flakes of skin, stray drops of sweat and bits of food. (Jam has a diabolical tendency to launch itself off toast.)

“What come in really, really handy are baby wipes,” astronaut Doug Wheelock said.

He also likes the Russian towels. They have a lot of texture, ideal for rubbing down a body. Without a shower, dead skin stays put and grows itchy.

“A towel with some texture on it is like heaven, because you can get all the dead skin off you,” Wheelock said. “It feels so good, psychologically.”

Astronaut Mike Fincke spent his downtime reading science fiction, including the Arthur C. Clarke novel [“2001.”](#)

Picture it: A man in a space station reading a novel about people on a space station. That closed a cultural loop.

“We take these dreams and make them real,” Fincke said.

The U.S. space vision

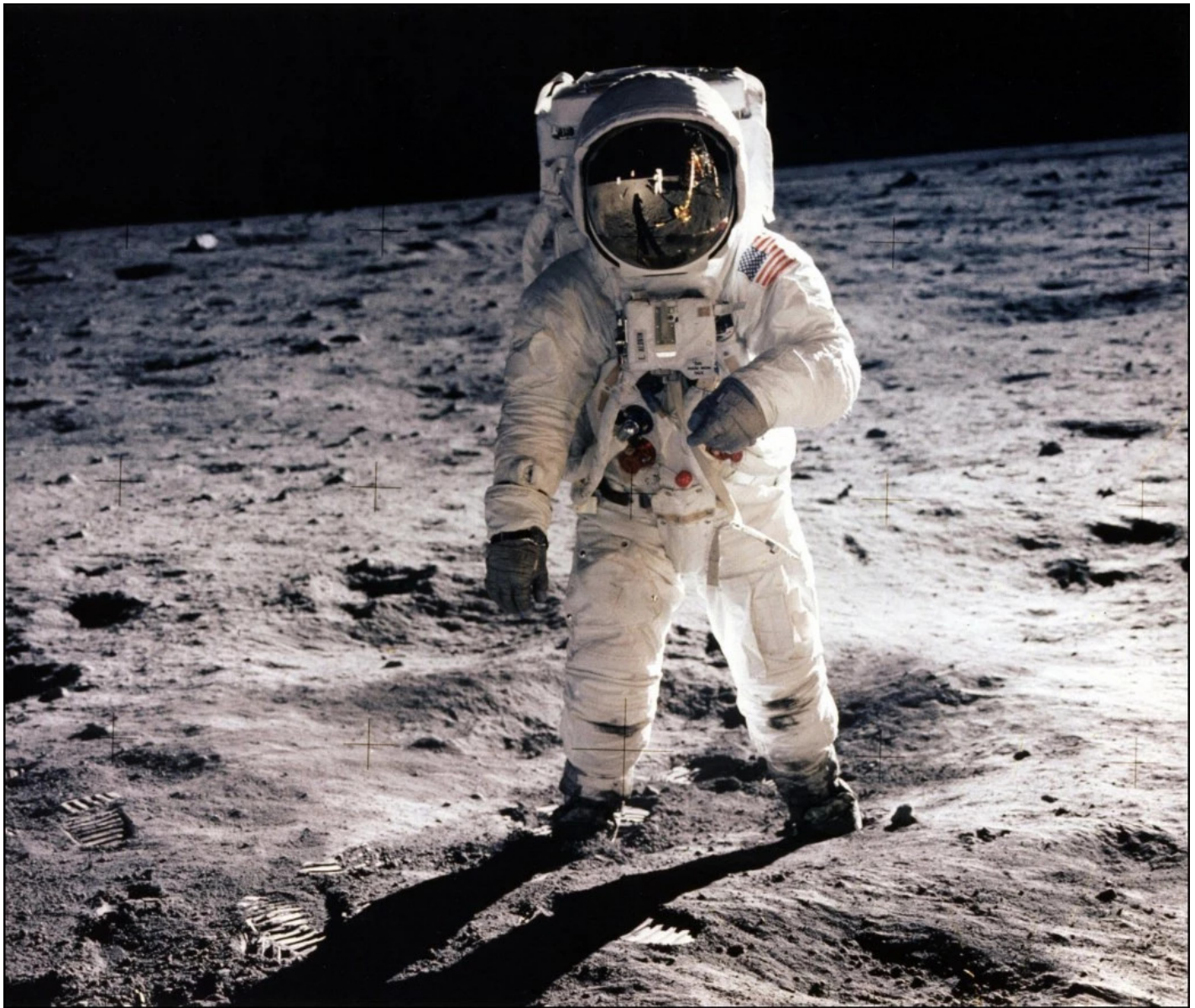
The space station’s flight control room at the Johnson Space Center in Houston. (Ricky Carioti/The Washington Post)

The international space station is another step in what space policy analyst Dwayne Day has called the Von Braun Paradigm, after Wernher von Braun, the German rocket scientist who, after World War II, came to America and became a leader of the U.S. rocket program.

In an influential series of stories in Collier’s magazine from 1952 to 1954, von Braun and other space visionaries foretold an era in which human beings would conquer space. Von Braun imagined a steppingstone approach that included orbital flights, a space shuttle, a space station, a voyage to the moon and, finally, a human landing on Mars.

Photos: NASA turns 55

From sending up satellites to putting a man on the moon, NASA has carried American ingenuity into space. Click on the image to view the gallery.



Neil Armstrong took this photo of astronaut Edwin E. Aldrin Jr., lunar module pilot, walking on the surface of the moon during the Apollo 11 mission in 1969. (NASA/AFP/Getty Images)

But the order of attack played out differently. The U.S. raced to the moon to beat the Soviets, who had their own lunar aspirations. NASA then wanted to build a space shuttle and a space station, but President Richard M. Nixon told the agency it couldn't do both. NASA went with the shuttle.

After aides mentioned to President Ronald Reagan that the Soviets had a space station, named Salyut, he decided that the United States needed one, too. In his [1984 State of the Union Address](#), he vowed to build a space station within a decade. "We can follow our dreams to distant stars, living and working in space for peaceful, economic and scientific gain," Reagan said.

Early estimates put the construction cost at \$8.8 billion, but the government spent roughly that much simply designing the laboratory on paper while Congress debated whether to build it, said Howard McCurdy, an American University professor of public affairs and author of "[The Space Station Decision](#)."

The collapse of the Soviet Union created the final incentive to go forward. U.S. officials worried that Russian rocket scientists would go to work for rogue nations, spreading missile technology. In 1993, the United States and its allies brought the Russians into the fold for what would now be called the international space station. The international agreements ensured that the funds would keep flowing to the project despite changes in administrations and turnover in Congress.

Russia launched the first module in the fall of 1998. After more than 100 rocket and space shuttle launches to ferry components to orbit, and an astonishing 160 spacewalks, the orbital laboratory — as broad as a football field, including end zones — was finally finished in 2011. The ISS is modular, with one main truss lined with protruding elements and framed by symmetrical solar arrays, the whole thing rather insectoid, like something that would make a buzzing sound if a tiny version flew by your ear.

During a deployment of solar arrays in 2007, one of the arrays suffered a tear. Astronauts on the station and engineers in Houston scrambled to come up with a solution, pressed for time before the array disintegrated. [In an emergency spacewalk](#), astronaut Scott Parazynski crawled to the remote end of a boom — farther from the air lock than any astronaut had ventured — and repaired the tear with makeshift “cuff links.”

“It was definitely a Superman moment,” said Mike Raftery, a top station official with Boeing.

A sociological truth has emerged from the international effort: American engineers are more likely to try to finesse a structure, to make it as lightweight and as efficient as possible, while Russians build things stout.

Mike Suffredini, the NASA program manager for the space station, said the station proves that in-orbit construction is possible, and he noted that no component has had to come back to Earth for retooling.

Said McCurdy: “It’s one of the greatest engineering achievements in the history of the world. It ranks with the pyramids.”

Logsdon, the policy analyst, said the station is a marvel, but he said it hasn’t yet proved it was worth the investment. The science has been going full speed only for a couple of years, so it’s too soon to make that judgment, he said.

“It’s an awfully expensive engineering demonstration,” Logsdon said. “If that’s all it is, that’s a hell of a price to pay.”

Gerstenmaier, the NASA official in charge of human spaceflight, said of the station’s cost: “We’re in the process of proving now whether it’s worth it or not. It’s going to take a little while to see if these researchers will embrace this facility.”

Walking on the edge

The helmet and gloves of an astronaut's Extra Vehicular Activity suit lie on the pool deck inside the Johnson Space Center's Neutral Buoyancy Laboratory, where astronauts train before heading to the ISS. (Ricky Carioti/The Washington Post)

The ISS almost cost one human life. Italian astronaut Luca Parmitano nearly [drowned in space](#) this summer. The astronaut, who represents the European Space Agency, was spacewalking outside the station on July 16 when he felt water on the back of his head. It didn't seem to be coming from his water bottle. It didn't feel like sweat. And it was increasing — and migrating, around his head, into his ears, around his nose, doing all the strange things that water does in zero gravity.

Spacewalks are exquisitely choreographed and are not supposed to include surprises. [The script for Parmitano's spacewalk](#) ran to 72 pages. Astronauts go through a 500-step process simply putting on their spacesuits, which function like miniature spaceships, with elaborate life-support gear and an emergency jet pack. An astronaut on the ground will continuously talk to spacewalkers to ensure that they are feeling well, thinking clearly. But now here was Parmitano telling Houston that his helmet was filling with water.

Parmitano's account [on his blog](#) is harrowing:

Video: Drowning in space



NASA aborted a July 16 spacewalk outside the international space station when Italian astronaut Luca Parmitano discovered a buildup of water in his helmet. (NASA)

“The water has also almost completely covered the front of my visor, sticking to it and obscuring my vision. . . . [T]he Sun sets, and my ability to see — already compromised by the water — completely vanishes, making my eyes useless; but worse than that, the water covers my nose — a really awful sensation that I make worse by my vain attempts to move the water by shaking my head. By now, the upper part of the helmet is full of water and I can’t even be sure that the next time I breathe I will fill my lungs with air and not liquid.”

He lost his sense of direction. Where was the air lock? He couldn’t even see the handles the astronauts use for maneuvering. He tried to contact fellow spacewalker Chris Cassidy — all spacewalks are tandem operations, for precisely this sort of situation — but he couldn’t hear him.

Then he recalled that his safety cable could be recoiled, and the gentle tug of that mechanism signaled the direction back to the air lock. He gradually felt his way there but still had to go through the laborious process of re-pressurization and reentering the station. NASA video captured the arduous efforts of Parmitano’s crew mates as they removed his helmet and towed up the rogue water.

NASA is still investigating where the water came from. Early evidence is that the spacesuit’s cooling system malfunctioned. The incident illustrated the obvious fact that there is nothing routine about life in space — that even after nearly five decades of spacewalks, and even with elaborate safeguards, a failure mode could lurk within the American spacesuits.

As Parmitano put it on his blog: “Space is a harsh, inhospitable frontier. . . . The skills of our engineers and the technology surrounding us make things appear simple when they are not, and perhaps we forget this sometimes. Better not to forget.”

Hadfield, who had left the ISS two months earlier, had a succinct description of what happened to Parmitano: “We just about killed him.”

‘Station’

Team members gather around a Soyuz spacecraft shortly after it landed in Kazakhstan on Nov. 19. Three astronauts returned from four months aboard the international space station. (Bill Ingalls/NASA via Getty Images)

Hadfield came back to Earth in May, retired from the astronaut corps — he had been a Canadian government employee for more than three decades — and retreated to his summer cabin on an island in the St. Clair River, which flows out of Lake Huron between Michigan and Ontario.

He can stand on his dock and watch the space station pass overhead. When you're an astronaut, you keep track of it and know when it's going to be visible. The best views are shortly after sunset.

"The station suddenly glows yellow, red, then winks out dark," he said. "It's really dramatic on board, and it's really beautiful to see it from here. It just echoes within me."



Canadian astronaut Chris Hadfield gestures shortly after landing in Kazakhstan on May 14. (Mikhail Metzel/AP)

Is there an aesthetic, even spiritual justification for spaceflight? So often, NASA officials describe the space station in practical terms, as a way of developing new technologies and expanding the economic sphere of the human race. But for someone like Hadfield, space travel offers humanity something that goes beyond any commercial or scientific utility.

"Station" — Hadfield often refers to it that way, as if it's a proper name — "is so much more than some remote laboratory where some small number of people and robots are doing something that no one knows about. Station is so much more than that. It is our first great human outpost in space. It is our way of seeing our world that's unprecedented in the history of the human species. It's an amazing platform for human self-discovery."

Conceivably, NASA could lease the station to some private, commercial operation, but it is hard to

imagine who might want to take up the cost of operating it. And all spacecraft get tired and creaky with age. Space is a harsh environment. Metal fatigue is inescapable, due to the expansion of the structure as the station moves in and out of sunlight.

So even if the station's life is extended beyond 2020, it is coming down, eventually. NASA could try to salvage a piece here and there, but there are no plans to deconstruct it, so the controlled de-orbit will be a spectacular, fiery event. Too big to burn up completely, the station will crash somewhere in the open water of the South Pacific.

It will be perhaps the most expensive man-made object that human beings have ever intentionally destroyed. This vision of the future will sink to the bottom of the sea, ending another chapter in the history of what people used to call the Space Age.

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